Description

Method for reproducing direct currents, and a DC/DC converter for carrying out the method

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The invention relates to a method for reproducing direct currents, in particular for use in DC switchgear, with the aid of a primary winding through which the direct current to be measured flows and which is magnetically coupled to a secondary

10 winding via an iron core, and to a DC/DC converter which is suitable for carrying out the method.

The detection of currents in DC circuits is associated with greater technical problems than such detection of currents in AC circuits, in which

15 transmission to a measurement device or to a tripping circuit of a switching device can be carried out using magnetic transformers.

Furthermore, there is the requirement for low-voltage switchgear for the measurement to be carried

20 out as far as possible from the system, that is to say without providing external energy from an additional energy source which provides an auxiliary voltage, which is likewise only a minor problem in AC networks, or at least with an energy source having only a low

25 power level.

It is known for the primary current to be measured using magnetic means, that is to say with the aid of Hall probes or magnetoresistive sensors.

30 However, it has been found that this method is not very suitable, at least for the preferred situation here, since the primary current cannot be reproduced with sufficient accuracy, and spurious tripping of the
... can thus easily occur.

It is also known for a measurement resistor (shunt) to be inserted in the primary circuit and for the voltage to be supplied via this measurement resistor to an isolating amplifier, whose output side

5　　acts on the tripping circuit. However, this solution is technically highly complex owing to the requirements which the isolating amplifier has to satisfy. Furthermore, there is a continuous, high power loss in the measurement resistor.

10　　EP-A 0 651 258 discloses a measurement method for direct currents, in which the primary conductor is magnetically coupled to a field winding via an iron core. The latter is energized with a regular, triangular-waveform alternating current, which allows

15　　pulses to be produced at regular intervals in a further winding, which is used as a measurement coil. If the iron core is now premagnetized in one direction or the other by means of the primary direct current, then the shift in the hysteresis curve of the iron core changes

20　　the interval between the measured pulses, and this can be evaluated as a measure of the primary current to be measured. This solution is likewise very complex in terms of circuitry and requires the continuous provision of an auxiliary voltage with a corresponding

25　　power level, thus resulting in a not inconsiderable energy requirement.

A further method for measuring direct currents is based on the use of a field winding to compensate for a magnetic field caused by the direct current in an

30　　iron core. The magnetic field in an air gap in the iron core is measured using a magnetic field sensor, in order to control the compensation current in the field winding. The current flowing in the field winding once compensation has been carried out, that is to say once

direct current. The method is known, for example, from EP-A 0 294 590 or from DE-A 38 15 100.

A further option with the aid of magnetic field compensation is described in UK-A 2 029 973. According to this solution, a current in the form of a ramp is fed continuously and repeatedly into the compensation winding, and the magnetic field in the iron core is measured via an indicator winding.

The compensation method likewise requires a considerable amount of energy to provide a continuous compensation current, and is thus not suitable for the abovementioned purpose.

The invention is based on the object of specifying a measurement method and, finally, a DC/DC converter, by means of which direct currents can be reproduced as accurately as possible and using considerably less energy.

According to the invention, the object is achieved by integration of the current signal which is supplied from the secondary winding of an iron core where the current to be measured flows through a primary winding, and by the integrated current value being supplied to a measurement device or to a tripping circuit of a switching device, with the integrated current value being trimmed at predetermined time intervals by determining the primary current to be measured with the assistance of a magnetic field sensor for measuring the magnetic field in the iron core, using the compensation method in which the magnetic field in the iron core is set to zero by means of a current, in the opposite direction to the primary current, in a compensation winding, and by the integrated current value being corrected to this value.

The method can expediently be carried out such that the secondary winding is used as the compensation winding for the measurement based on the compensation

The compensation method can advantageously be carried out such that a linear-rising direct current is fed into the secondary winding or into a separate compensation winding.

5   The method manages with only a fraction of the energy required by previously known DC/DC converters, since the compensation method is carried out only at time intervals in order to compensate for the drift in the current value determined using the integration
10   method.

According to the invention, a DC/DC converter which is suitable for carrying out the method has a primary winding, through which the primary direct current to be measured flows, and a secondary winding,
15   which windings are magnetically coupled via an iron core, and has a magnetic field sensor for measuring the magnetic field of the iron core, an integration circuit which is connected to the secondary winding and whose output is connected to a measurement device or to a
20   tripping circuit of a switching device, and a compensation circuit which is connected to the secondary winding via a changeover switch, or is connected to a separate compensation winding wound on the iron core. This compensation circuit comprises a
25   controllable DC source and an evaluation circuit which processes the current value of the DC source when the magnetic field has been compensated, that is to say when the magnetic flux is equal to zero, in order to trim the integration circuit.

30   The magnetic field sensor may be a Hall probe, a magnetoresistive sensor or an indicator winding into which a balanced alternating current is injected and whose voltage imbalance or balance is a measure of the magnetic field in the iron core.

The iron core is expediently provided with an air gap, in which or in whose vicinity the magnetic field sensor is arranged.

The secondary winding supplies a signal which corresponds to the di/dt of the primary direct current. The downstream evaluation circuit, preferably based on a microprocessor, integrates the signal from the secondary winding to form the primary direct current, and can use this value in a known manner to carry out the overcurrent protection.

Determination of the primary current necessitates long-term integration, in which minor errors over very long times can lead to major discrepancies between the calculated value and the true primary current, so that an overcurrent release would operate unnecessarily. In order to avoid this undesirable long-term effect, the current is measured at certain time intervals with the aid of the magnetic field sensor. For this purpose, a direct current which starts from zero and ramps up linearly with time is fed into the secondary winding or into a separate compensation winding. At the same time, the output signal from the magnetic field sensor is monitored. When a reversal point or a change in polarity occurs in the signal, depending on the type of magnetic field sensor used, then the magnetic field in the air gap is zero, and the compensation current, multiplied by the number of turns on the secondary or compensation winding, is equal to the primary current, which is then used to correct the previously integrated current value. After this, the current can once again be detected by integration.

If an indicator winding on the iron core is used for the magnetic field measurement, then a

not equal to zero, then the magnetic characteristic of the iron core results in the voltage being imbalanced to a greater or lesser extent. When the magnetic field finally becomes zero as the compensation current rises,

5   then this results in a balanced AC voltage. The sought measurement point has then been reached. In contrast with the compensation method described in relation to the prior art, there is no need to control the compensation current in this case. In fact, the

10   measurement process can be terminated once the linear-rising compensation current has resulted in the magnetic field in the iron core becoming zero.

The use of such an indicator winding has the advantage over other magnetic field sensors that it is

15   considerably more resistant to temperature. The temperature resistance depends only on the insulation class of the winding. Overtemperatures up to 200°C may be acceptable, with appropriate insulation.

The invention will be explained in more detail

20   in the following text with reference to an exemplary embodiment. In the associated drawings:

Figure 1 shows an outline illustration of the arrangement required for the DC/DC converter,

Figure 2 shows the signal produced during

25   regular trimming with various magnetic field sensors,

Figure 3 shows a block diagram of an arrangement for compensation measurements.

Figure 1 shows an outline illustration of the

30   arrangement which is required to carry out the method. A primary electrical conductor 1 of a DC network is passed through an iron core 2 of the DC/DC converter. The iron

core 2 is provided with an air gap 3 in which a magnetic field sensor 4 is accommodated. A secondary winding 5 is fitted to the iron core 2, and its current supplies the signal to be evaluated. The current signal

5   is integrated in an integration circuit, which is not shown here, and then supplies a model of the primary direct current I_{Prim}.

In order to trim the integrated current value, a second current measurement is carried out with the

10 aid of the magnetic field sensor 4. For this purpose, the current measurement process carried out until that point in time is briefly interrupted and a linear-rising compensation current I_{sec} is fed into the secondary winding 5 until the output signal $I_?$ of the

15 magnetic field sensor 4 reaches a reversal point or a polarization change, as is shown in figure 2. The compensation current I_{sec} multiplied by the number of turns w corresponds to the primary direct current I_{Prim} to be measured. The current value, which was previously

20 determined by means of integration, is now corrected using this measured value.

Figure 3 shows one option for obtaining the field measurement in the iron core 2. The secondary winding 5 is in this case used as a compensation

25 winding. The illustration shows only operation during the compensation phase. The secondary winding 5 is connected to a controllable DC source 6 which, for example, feeds a linear-rising current into the secondary winding 5.

30 A balanced alternating current, which is supplied from an AC source 8, is fed into an indicator winding 7. The voltage across the indicator winding 7 is measured. In the positive half-cycle, the positive peak value is stored in a peak-value store 9, and in

suitable for use as the peak-value stores. The two values are then compared in a comparator 11.

If the comparator value is not equal to zero, this means that the voltage is unbalanced, owing to the

5   magnetic characteristics of the iron core 2 which has been premagnetized by the primary current I_{Prim}.

If the comparator value is zero, then the measured AC voltage across the indicator winding 7 is balanced, and is thus a measure that the magnetic field

10   in the iron core is zero, that is to say the primary direct current I_{Prim} has been compensated. The current I_{Sec} in the secondary winding 5 is, at this instant, a measure of the primary direct current I_{Prim}. The value is retained in order to use it subsequently to correct

15   the current value obtained using the integration method. The integration process and the current value correction are expediently carried out digitally in a microprocessor, which is not shown here. For use in a tripping circuit of a DC switching device, the tripping

20   circuit is in any case already equipped with a microprocessor, which can also be used for this purpose.